63-2-5

NOLTR 62-185



# ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS



NOL

21 NOVEMBER 1962

UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

NOLTR 62-185

# ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS

Prepared by:

R. J. Urick

ABSTRACT: Underwater objects always acquire a growth of marine organisms when left in the water for a period of time. When a natural growth of fouling occurs on a hydrophone, a reduction of its sensitivity and a deterioration of its beam pattern may be expected. In order to estimate the severity of these effects, a small selection of hydrophones were measured after they had remained in Chesapeake Bay during the growing season of 1961. Measurements of beam pattern and receiving response were made in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to 10 db were found in the frequency interval 1 to 20 kc. Appreciable, though not severe, effects of the fouling on the hydrophone beam patterns were observed. Additional work is needed for making prediction estimates for surveillance systems or other uses.

Physics Research Department
U. S. Naval Ordnance Laboratory
White Oak, Silver Spring, Maryland

A virtually unknown aspect of underwater acoustics concerns the effect of fouling by marine organisms on the acoustic performance of transducers. This report describes the degradation produced by marine growth on a number of hydrophones that had accumulated a summer's growth of fouling in Chesapeake Bay. A tentative hypothesis to explain the observed effects is described. The work was done as part of the Laboratory's Foundational Research Program.

The work described in this report is in large part that of other individuals. Grateful acknowledgement is made to Dr. F. Swartz of the Chesapeake Biological Laboratory for his careful description of the fouling organisms; to Mr. J. J. Greene of NOL Test Facility, Solomons, Md. for mounting, placing and removing the units; and to Mr. P. C. Rand of the NOL Acoustic Facility, Brighton, Md. for making the acoustic measurements.

R. E. ODENING
Captain, USN
Commander

Zaka I Slawsky

Z. I. SLAWSKY
By direction

## TABLE OF CONTENTS

## FIGURES

## INTRODUCTION

Like other underwater objects, transducers for producing or receiving sound soon acquire a growth of biological organisms when left in the sea for any length of time. Such biological fouling may be expected to be a normal occurrence on units that remain on the bottom for a period of time, such as transducers used for surveillance purposes. The fouling may be expected to produce a deterioration in the performance of the transducer, as well as to affect both its sensitivity and directional characteristics. One would guess that a fouled transducer would be less sensitive and less directional - both as to its main beam and side lobe characteristics - than the same unit after the fouling is removed. A layer of barnacles, oysters, polyps, etc., would both attenuate and scatter sound so as to deteriorate the performance of the transducer on which the layer is growing. While this is the expectable effect, its magnitude is unknown. For example, it is not known whether a relatively light growth of organisms has any practical importance, nor is it known when a transducer must be removed for cleaning off of its active face. The literature on the subject is practically non-existent (see Appendix). Fig. 1 is an example to show what happens to a hydrophone when left in the water for some months at a location especially favorable for biological growth.

## MEASUREMENT PROCEDURE

A number of transducers of different types were placed in Chesapeake Bay at the NOL Test Facility at Solomons, Md. The water depth at the site was 10 feet, and the location was one of gentle tidal currents. The various hydrophones were fastened to a frame and placed in the water on May 26, 1961. They were kept there until October 20, 1961, when the units were removed for measurement. A nearly full growth of organisms took place during this period of about 5 months. A longer stay in the water would have incurred the risk that some of the attached growth would be killed by the rapidly falling temperature of the water.

The hydrophones were removed from the mounting frame, wrapped in soft wet burlap wadding and carried by truck to the NOL Brighton Dam Acoustic Facility for measurements. This involved a two-hour trip, with measurements that same day for many of the units, and at most a delay of 24 to 30 hours between removal and measurement. Immersion in the fresh water of the calibration site was kept to a minimum, not exceeding 2 hours.

Measurements of frequency response and beam pattern were made with the regular equipment of the Station, first in the fouled condition and then in the clean condition after removal of biological growth. Pen-and-ink records for the two cases were made on the same sheet with all other conditions (gains, distances, etc.) remaining the same, so that the differences in response that are of immediate concern become readily apparent. A thorough biological description of the growth on the transducers was provided by Dr. F. J. Swartz of the Chesapeake Biological Laboratory, through inspection and study of the hydrophones shortly before final removal.

A small selection of receiving hydrophones was used for the study. One type, called Hydrophone No. 1, was a line hydrophone approximately two feet long, comprising an array of twelve coaxially mounted ceramic cylinders. Hydrophone No. 2 was the well-known AX-58 hydrophone, with preamplifier, widely used in low frequency underwater sound measurements. Hydrophone No. 3 was an ADP flat-faced transducer 13 inches in diameter, designed and made by NRL under the designation XQB, having a sharply resonant response at 26 kc. Finally a number of small broad-band ceramic hydrophones (Hydrophone 4) of uncertain design and unknown designation were tested. Photographs of these various units are given later in this report.

DESCRIPTION OF THE FOULING

As will be seen from the photographs to follow, all the hydrophones had accumulated a greater or lesser amount of biological growth by the time they were removed and measured. On some hydrophones, notably the type designated No. 1, a complete covering of dense growth was formed; on others, notably the hydrophones No. 4, the growth was sparse. The growing organisms were principally of three types: soft jelly-like lumps 1/3 to 1 inch in diameter, identified as sea squirts (*Mogula manhattensis*); hydroid strands of coarse, soft, hairy-like material, identified as *Bouganvillia carolinensis*; and barnacles, 1/4 - 3/4 inch in size, (*Balanus improvisus*). In addition, occassional waifs were found in this mass of material, notably a few small mud crabs, mussels and sea anemones.

Although these organisms were encountered on all hydrophones, the amount and proportion of the three principal constitents of the population differed among the various hydrophones, probably as a result of a different composition of the transducer face material, and the acoustic effects produced differed among the various units.

## SUMMARY OF RESULTS

Appendix II gives a selection of frequency response curves and beam patterns for the various hydrophones, together with a description of the hydrophone and the type of fouling encountered. Two curves, one fouled and one clean, are shown on each figure for comparison. Other frequencies and orientations besides these included were measured, but the figures included give a fair sample of what was found for the various units.

The acoustic effects of the fouled growth may be summarized as follows. On the hydrophones tested the fouling appears to produce

(1) a reduced axial sensitivity (receiving response) by amounts ranging from 0 to 10 db, with the greatest reduction in the frequency band of maximum response.

(2) a deterioration in beam pattern, in which the reduction of sensitivity is less for the side lobes than for the main beam. Thus, the side-lobe discrimination is less in the fouled condition than in the absence of fouling.

(3) sometimes, a smoother beam pattern, with the deep dips of the clean pattern "filled up" in the fouled condition.

(4) no effect on the response of a small "point" hydrophone (No. 4) as contrasted to arrays like Nos. 1 and 3.

## DISCUSSION

The measurements made here throw only a little light on the processes by which an attached fouled layer affects the open-circuit response of a hydrophone. A number of processes may be imagined, all of which may contribute to producing the observed effects. First, the fouling may behave merely as a homogeneous slab of material between the water on one side and the sensitive element on the other, so as to produce a transmission loss and an effect on the receiving response; this process is, however, probably insignificant, since the fouling has neither the homogeneity, thickness, nor the density and velocity contrast required to have an appreciable effect. A more important effect would be produced by the mass loading of the fouling on the vibrating hydrophone elements. Because of the uneven distribution of growth, this loading will be different on different portions of the sensitive area, and would not only tend to reduce the sensitivity of the vibrating elements irregularly, but would destroy the

regularity of phase needed to form a good beam pattern. A third effect is absorption and scattering by gas pockets in and among the living organisms. Finally, and perhaps most important, hard growths like barnacles and oysters would tend to scatter the incident sound and so change the phase response of the individual elements of the array.

The data suggest that fouling (of the type encountered here) on a hydrophone array has its principal acoustic effect in destroying the phase equality needed to form a directional beam. The most reasonable explanation of the data is that the fouled growth produces scattering and/or differential loading on the array elements, and thereby destroys the equality of phase in the direction of the beam axis. This hypothesis is suggested by (1) the absence of notable fouling effects on the small (6") hydrophone (No. 4), (2) the greater reduction of sensitivity on the beam axis than on the side lobes of directional patterns (No. 3), and (3) the smaller effects at high frequencies, above the frequency band of maximum response, than at low (No. 1). In other words, the fouled growth appears to randomize the phase response of the array elements, and so change the delicate phase equality along the beam axis required for a well-formed beam pattern.

It will already have been apparent that the work described is insufficient to make anything more than a guess as to what to expect for other hydrophones placed in other locations. This calls for an understanding of the acoustic processes involved, as well as an estimate of the type and amount of growth to be expected on the surface of the hydrophone - which may or may not have been chemically treated to retard fouling. Estimates of this sort might be based on studies like those made by the Hydrographic Office on the types and growth of fouling off Norfolk, Va. (see Appendix I).

A subject entirely neglected so far is the effect of fouling on sound projectors, as contrasted to hydrophones, especially on resonant, tuned projectors, where the growth would change the radiation impedance of the transducer and produce a mis-match to the impedance of the power source. Thus, what has been described here should be viewed as the results of a short pilot study intended only to give an indication as to order of magnitude of the expectable effects. Much additional work is needed before valid predictions can be made. Such predictions may be urgently needed at any time in the near future in connection with shallow-water surveillance systems.

## SUMMARY

A small number of hydrophones of four different types, placed in a biologically favorable area and left to accumulate a fouled growth during an entire growing season, showed reductions of axial sensitivity of between zero and 10 db depending upon the hydrophone, the amount of fouling, and the frequency. In addition, the side-lobe pattern shows some tendency to become smoother, with the side-lobe peaks tending to become higher, relative to the main lobe, in the fouled condition. The measurements suggest that the principal acoustic effect of the fouling is to destroy the phase relationships among the elements of the array, as by scattering or differential loading. However, this brief study has yielded only a suggestion of the acoustic processes involved, and provides merely a start toward prediction of the fouling effects to be expected at other locations.

## APPENDIX I

Only two references to the degrading of performance produced by fouling on transducers (rather than sonar domes, which have been greatly studied) have been found. In NDRC Summary Technical Report Div. 6, Vol. 12, "Crystal Transducers", it is said that measurements on a magnetostrictive UCDWR Type CQ6Z transducer (which had accumulated a 3-4 month growth of fouling) showed that the transmission was "very materially reduced" and the directivity patterns were "very badly distorted". No details or quantitative data are given. Another reference to the effects of fouling is a report by J. W. Fitzgerald and others, "Corrosion and Fouling of Sonar Equipment" Part I, NRL Report 2477, Mar 1947 (Unclassified), where the problem of prevention of fouling of sonar transducers was described and attacked. This report quotes some observations of fouling effects on a JK-1 transducer made by W. K. Lyon of the USN Radio and Sound Laboratory (the predecessor of NEL) and reported in an internal memorandum of that Laboratory.

Two reports on the biological fouling to be expected in the open ocean near the mouth of Chesapeake Bay are the following:

W. E. Maloney "A Study of the Types, Seasons of Attachment and Growth of Fouling Organisms in the Approaches to Norfolk, Va.", U. S. N. Hydrographic Office Tech. Report 47, 1958.

F. M. Daugherty, Jr. "Marine Biological Fouling in the Approaches to Chesapeake Bay", U. S. N. Hydrographic Office Tech. Report 96, 1961.

## APPENDIX II

In this appendix, a number of beam patterns and response curves for the four hydrophones tested are given, together with a short description of the hydrophone, the fouling, and the acoustic effects observed. It will be noted that the hydrophones consist of two array types, one linear (No. 1) and one planar (No. 3), and two "point" types (Nos. 2 and 4) for which the sensitive portion is relatively small in size. The patterns and response curves given are photographs of those obtained by Mr. Rand, in which the traces for the fouled and cleaned unit were made on the same record sheet with the same gain settings.

## HYDROPHONE NO. 1

Type: No designation

Description: Array of twelve cylindrical ceramic elements; overall length of the active portion 22 inches.

Frequency Response: Gently falling sensitivity in the region 1 to 20 KC, with the fouled sensitivity less by amounts ranging from 3 to 12 db.

Beam Pattern: There is a slight widening, amounting to a few degrees, of the main beam at 20 kc. The fouled patterns are smoother than the clean, with reductions of sensitivity on the side lobes and an absence of deep dips at the nulls. These occur generally at the same angles. The reduction of sensitivity is somewhat greater for the main beam than for the sidelobes, so that in this regard there is a deterioration of the pattern in the fouled condition. There is only a slight variability in the pattern in the plane at right angles to the hydrophone axis.

Description of Fouling: Heavily fouled. Sea squirts covered the entire surface of the unit, together with hydroid strands averaging about an inch in length. Scattered as undergrowth to this material were barnacles occupying about a fourth of the face area, and a few mud crabs and mussels.

## HYDROPHONE NO. 2

Type: BM-111A(AX-58)

Description: Crystal unit approximately 4 inches long

Frequency Response: Fouled sensitivity is 4 db less in the region 3-10 kc; the difference between the fouled and clean sensitivity diminishes to zero above 15 kc (where the response is some 15 db less than below 5 kc) and below 2 kc.

Beam Pattern: At 5 kc, pattern is nearly circular for both cases, with a difference between 3 and 7 db. At 20 kc, the fouled pattern shows reductions on the lobes, with little or no reduction in sensitivity at the nulls. The "filling-in" of the nulls is particularly pronounced at 40 kc. The pattern is poor in both cases at these frequencies; this unit was intended to be a low-frequency, non-directional hydrophone.

Description of Fouling: 10% of the surface area was covered with barnacles, and 10% area was covered with hydroids (Bryozoans, sea squirts). Remainder of transducer face unfouled. Brass top cap, however, was completely fouled.

## HYDROPHONE NO. 3

Type: NRL type XQB

Description: Flat faced crystal mosaic, tuned at 26 kc, diameter 13 inches.

Frequency Response: Response is 4 db less in fouled condition at the 26 kc resonance peak. There is an increasing difference toward lower frequencies, becoming 8 db at 7 kc, and decreasing difference toward higher frequencies, becoming only 1 db at 40 kc.

Beam Pattern: Very little deterioration of the pattern. At 26 kc, the fouled pattern is even somewhat superior, with lower sidelobes than the cleaned pattern. The width of main beam is the same before and after fouling.

Description of Fouling: Face covered almost completely with small barnacles 5-6 mm diameter (Balanus improvisus), on top of which were large sea squirts. Large patches of dead barnacles are evident in the photograph.

## HYDROPHONE NO. 4

Type: No designation

Description: Ceramic cylindrical unit 6-inches long.

Frequency Response: No difference between the fouled and cleaned condition apparent below 7 KC. Above this frequency, where the response begins to fall off, the difference amounts to only 1 to 2 db.

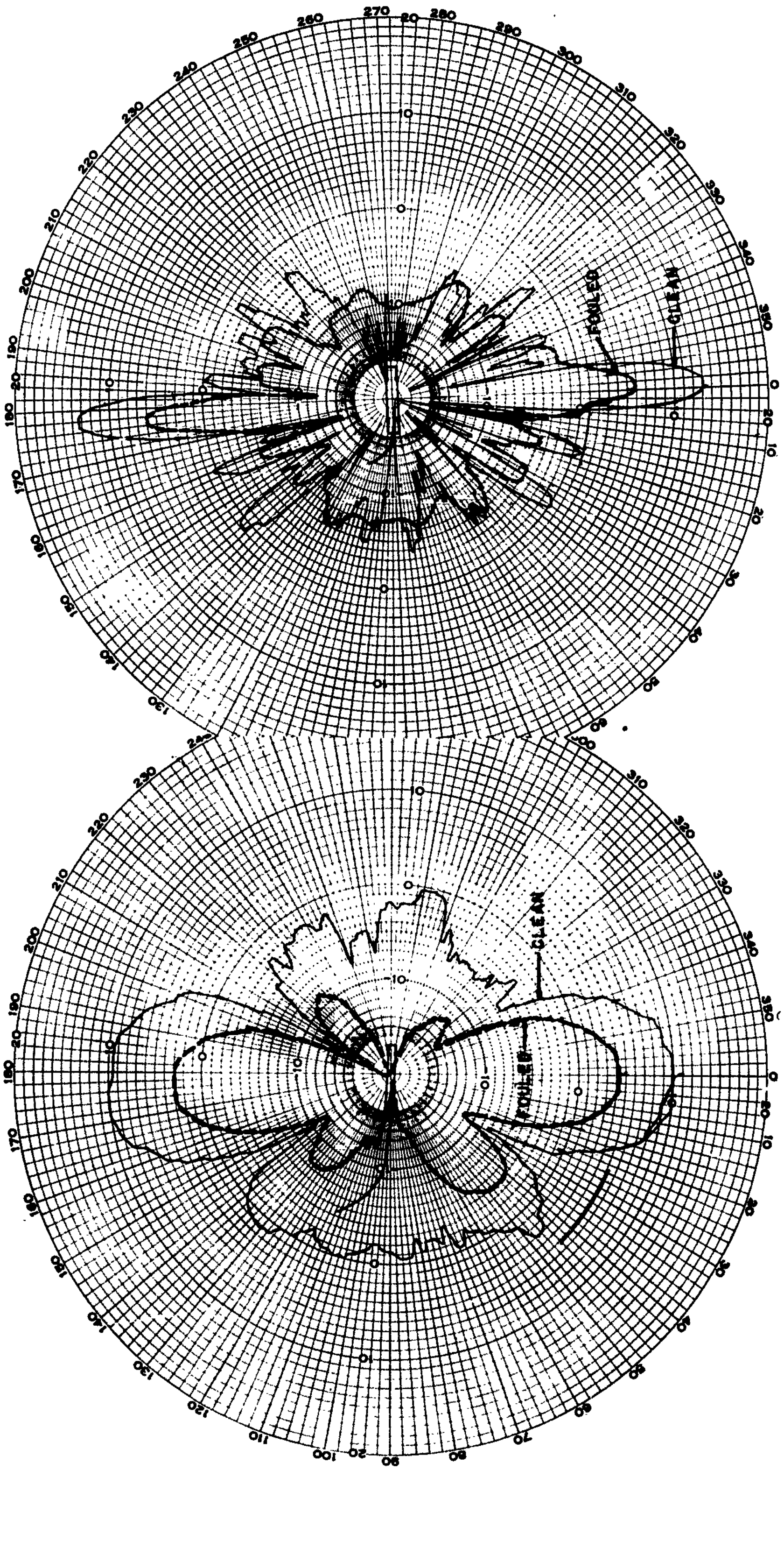
Beam Pattern: Pattern is nearly circular at 5 KC, with not more than 1 db of difference, fouled and cleaned, At 20 KC, the patterns are also essentially similar, with similar nulls and main lobes, although as much as 5 db of difference exists on the side lobes.

Description of Fouling: Unit was only slightly fouled. Approximately 10% of area was covered by barnacles, with a 5 - 15% covering of sea squirts.

FIG. 1 A HYDROPHONE ON REMOVAL FROM IMMERSION FOR A PERIOD OF 13 MONTHS IN ST. ANDREW'S BAY, PANAMA CITY, FLA. THE LARGE SHELLS ARE OYSTERS, THE SMALL CIRCULAR SHELLS ARE BARNACLES. THIS PHOTOGRAPH IS INCLUDED TO SHOW AN EXTREME CONDITION OF FOULING; THE HYDROPHONE WAS NOT AMONG THOSE MEASURED FOR THIS REPORT.

FIG 2 HYDROPHONE NO 1, FOULED

FIG. 3 HYDROPHONE NO. 1 CLEANED




20 KC

5 KC

FIG. 4 HYDROPHONE NO. 1, PATTERNS IN PLANE CONTAINING THE AXIS AT 5 KC AND 20 KC.

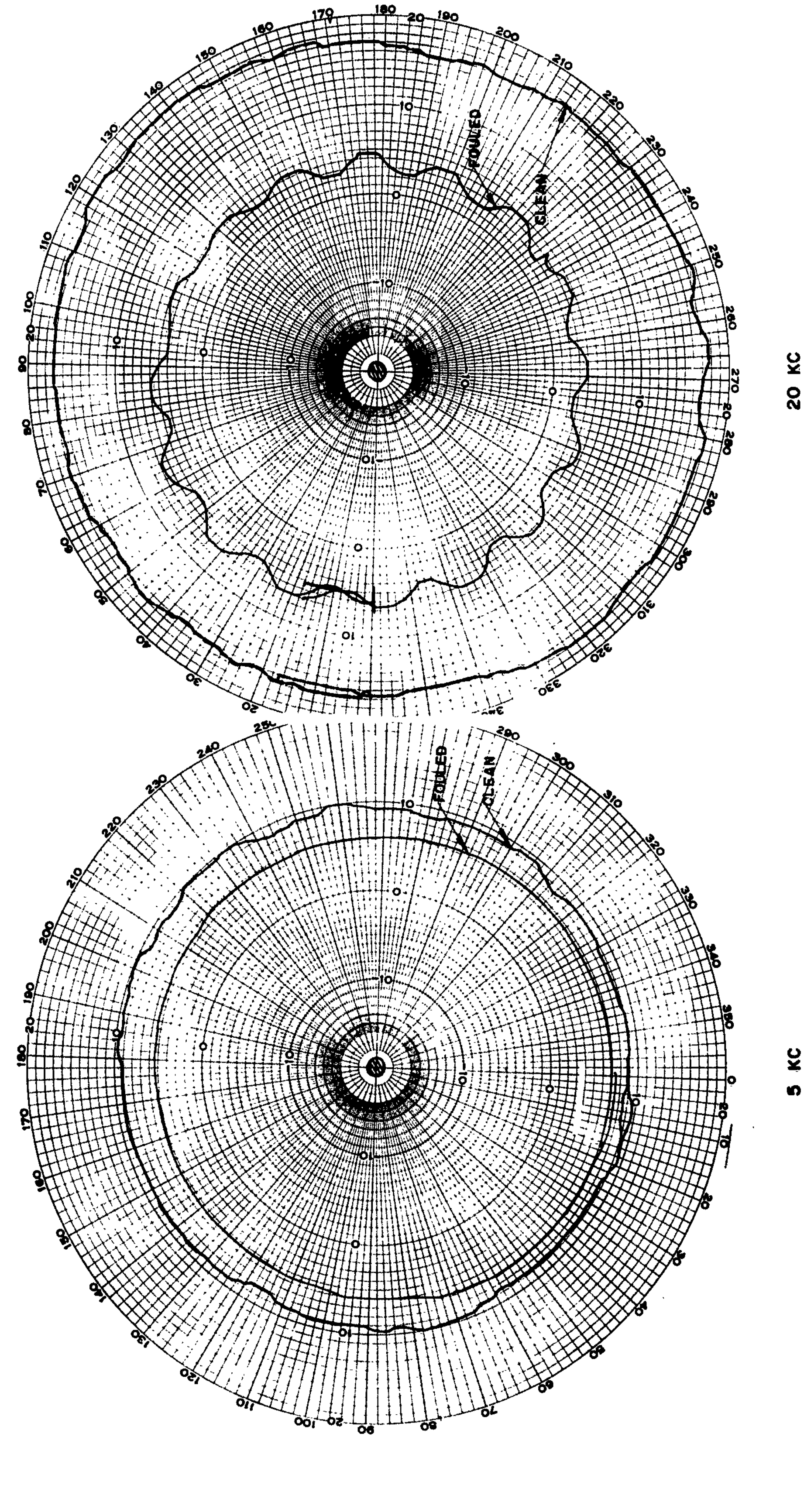



FIG. 5 HYDROPHONE NO. I, PATTERNS IN PLANE AT RIGHT ANGLES TO AXIS AT 5 KC AND 20 KC.

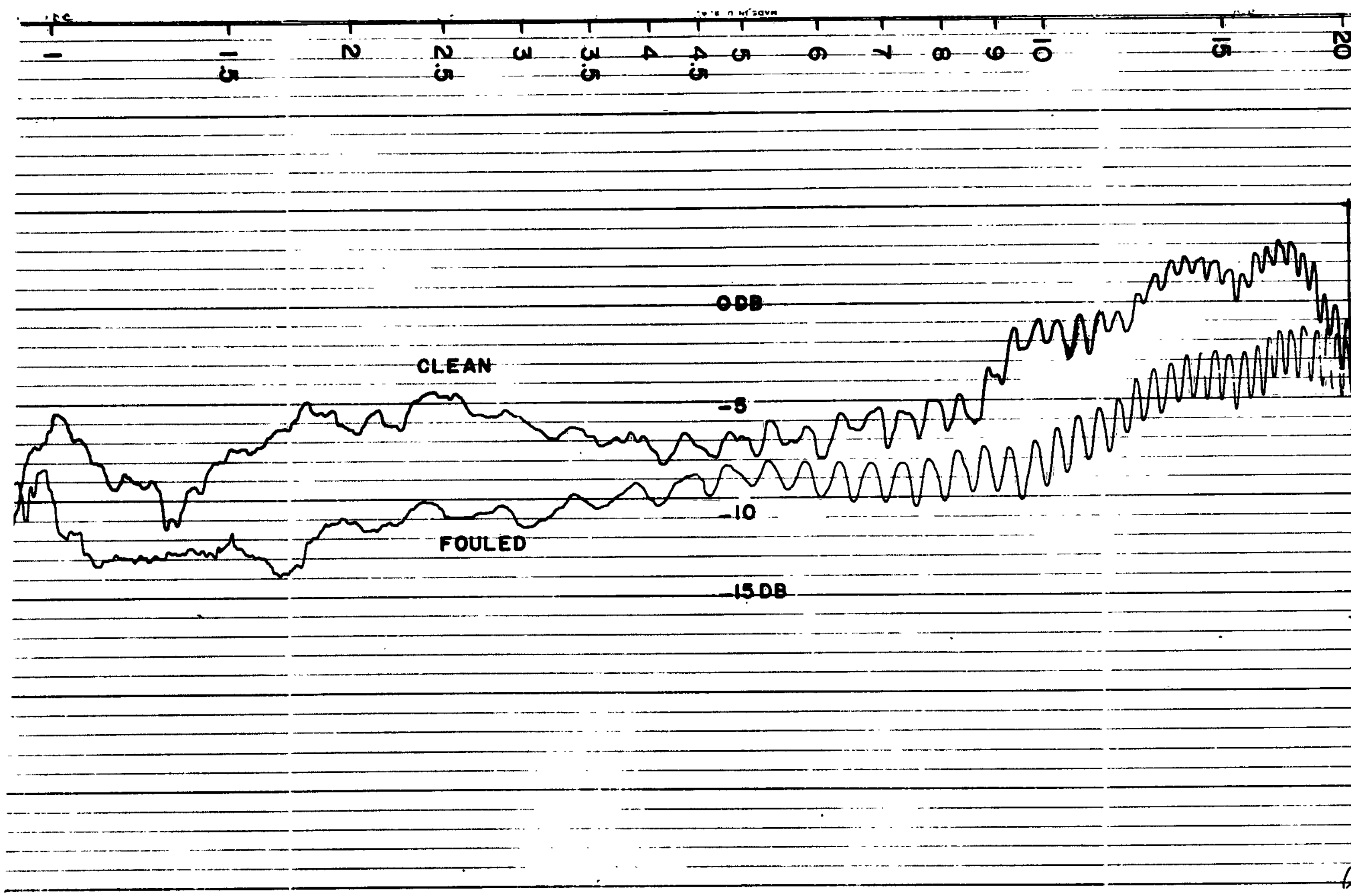



FIG. 6 HYDROPHONE NO. 1, AXIAL RESPONSE CURVES, 1-20 KC.

FIG. 7 HYDROPHONE NO. 2 (RIGHT HAND SIDE, PARTIALLY VISIBLE) AND HYDROPHONE NO. 4 (LEFT HAND SIDE, CLUSTER OF UNITS), FOULED.

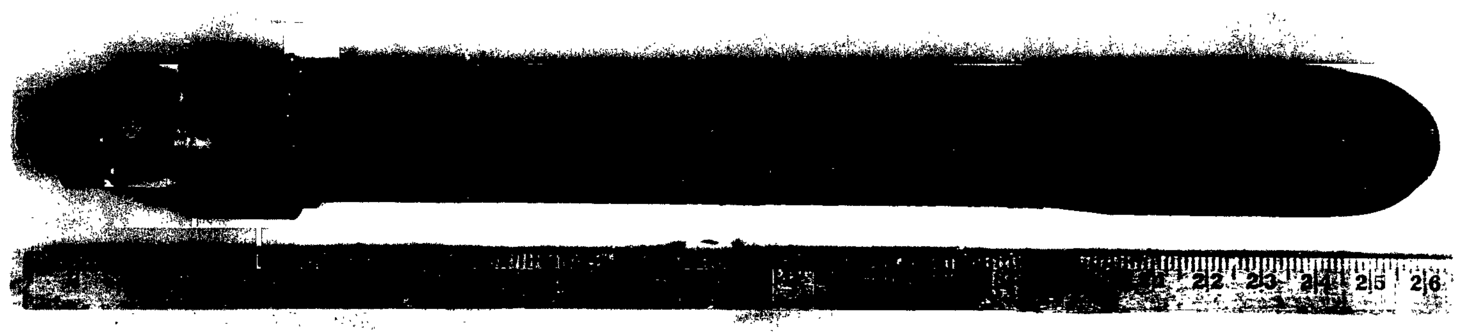
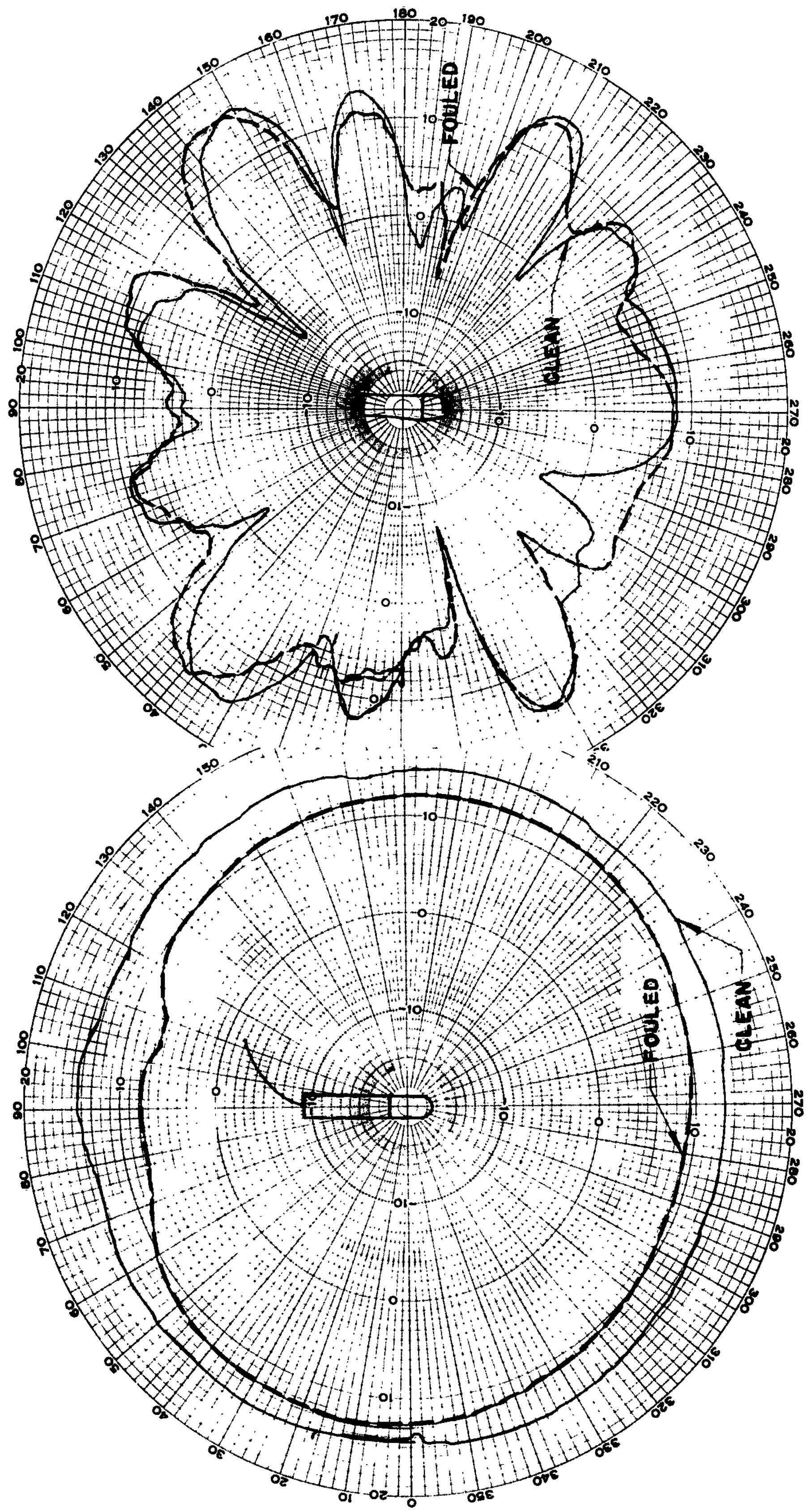


FIG. 8 HYDROPHONE NO. 2, CLEANED. SENSITIVE PORTION AT BOTTOM; REMAINDER IS A PRE-AMPLIFIER.




40 KC

5 KC

FIG. 9 HYDROPHONE NO.2, PATTERNS IN PLANE CONTAINING THE AXIS AT 5 KC AND 40 KC.

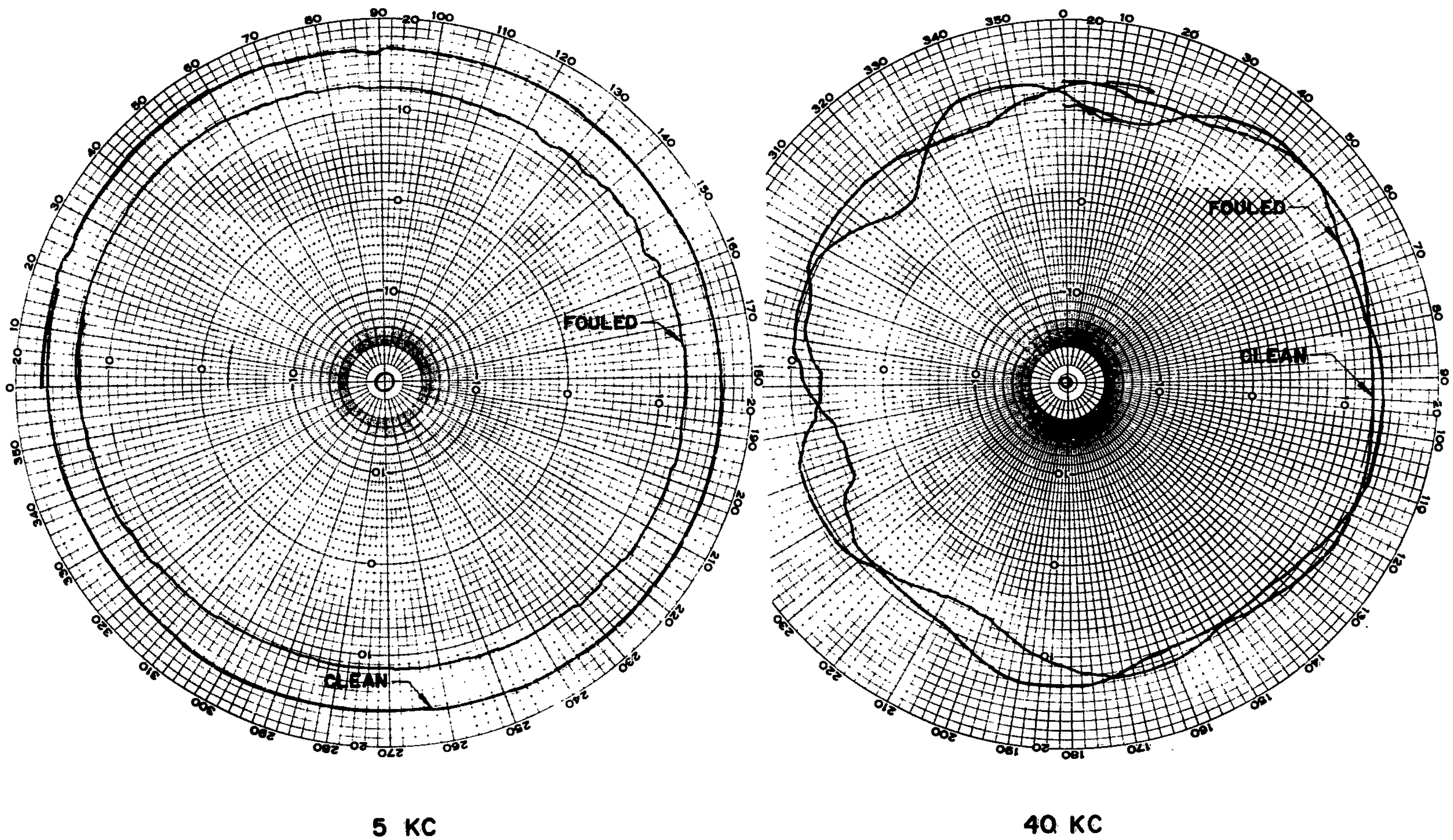



FIG. 10 HYDROPHONE NO. 2, PATTERNS IN PLANE AT RIGHT ANGLES TO AXIS, 5 AND 40 KC.

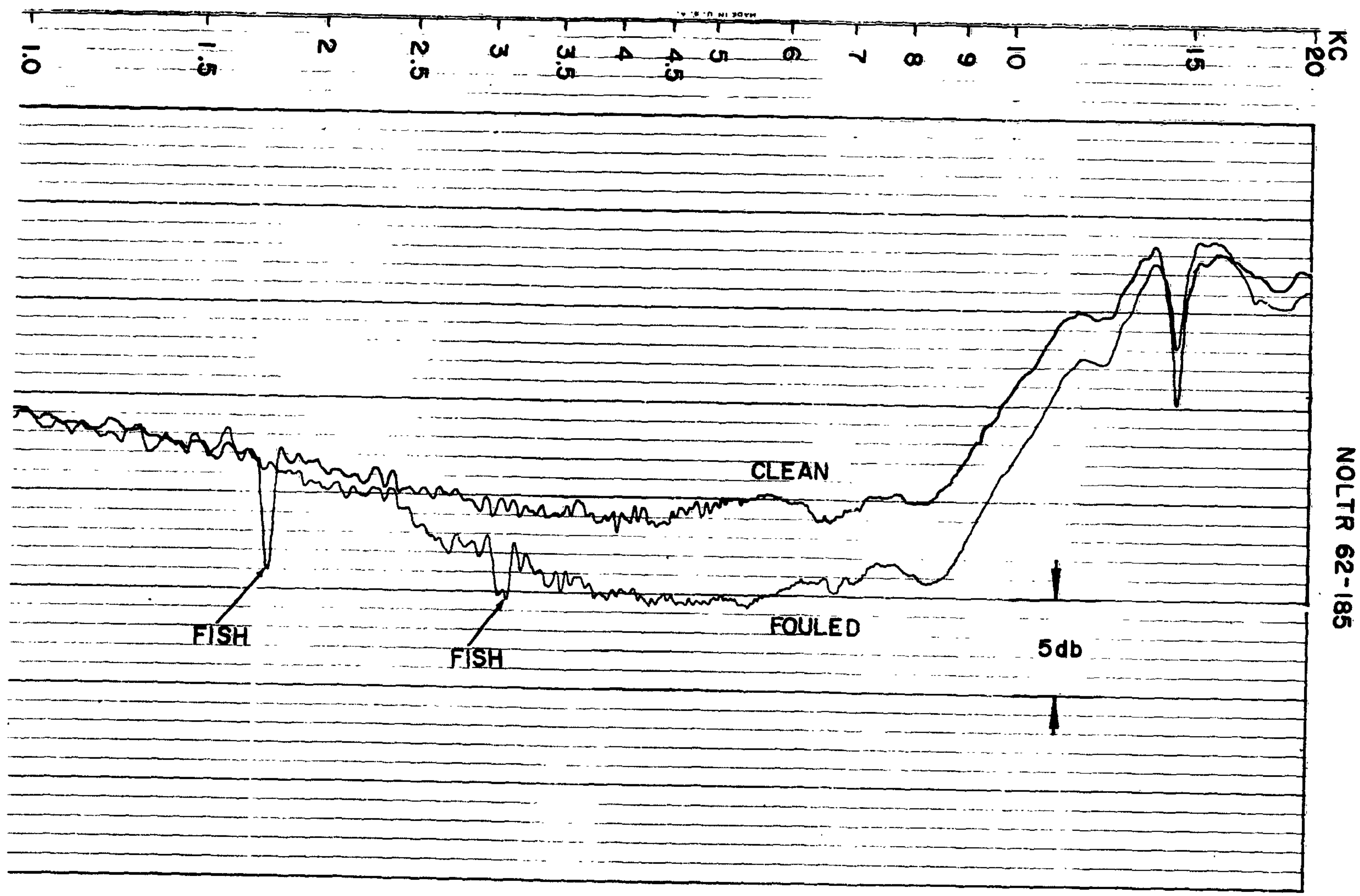
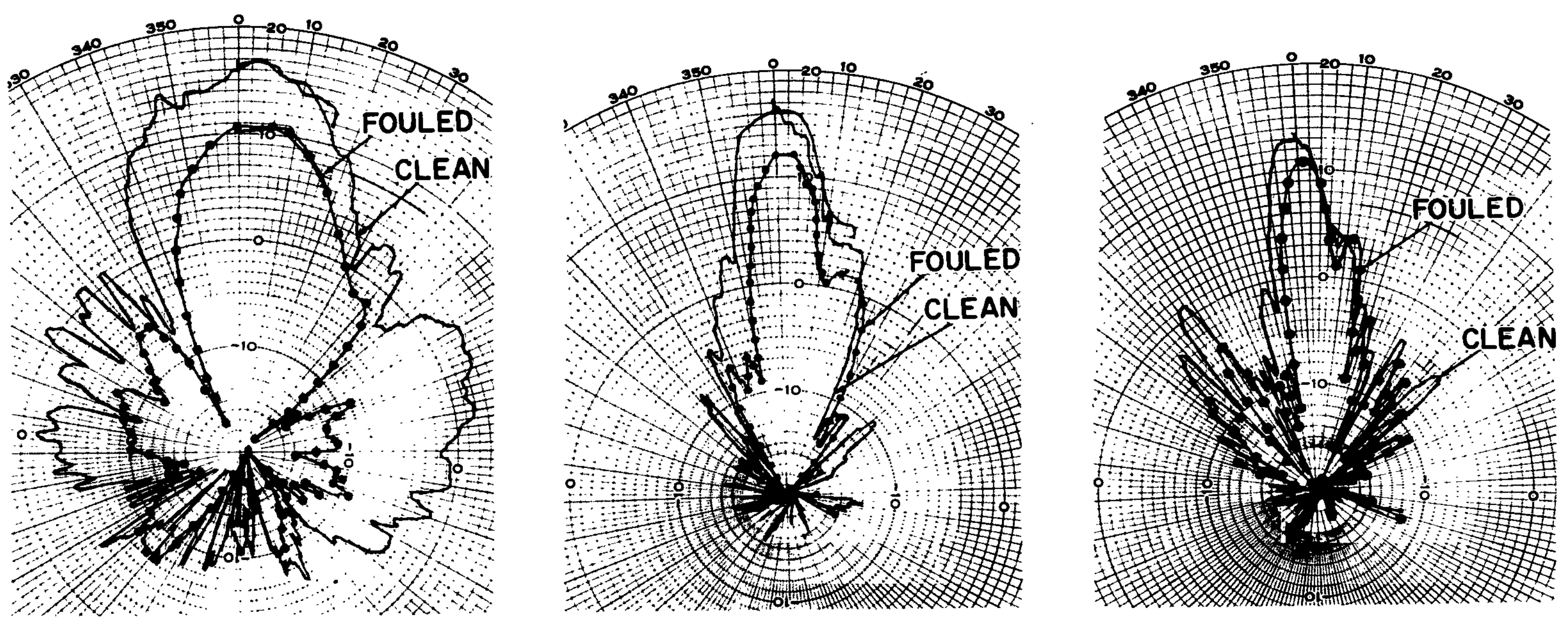



FIG. 11 HYDROPHONE NO. 2, AXIAL RESPONSE CURVES, 1-20 KC.

FIG. 12 HYDROPHONE NO. 3, FOULED

FIG. 13 HYDROPHONE NO. 3, CLEANED




10 KC 26 KC 40 KC

FIG. 14 HYDROPHONE NO. 3, BEAM PATTERNS AT 10, 26 AND 40 KC.

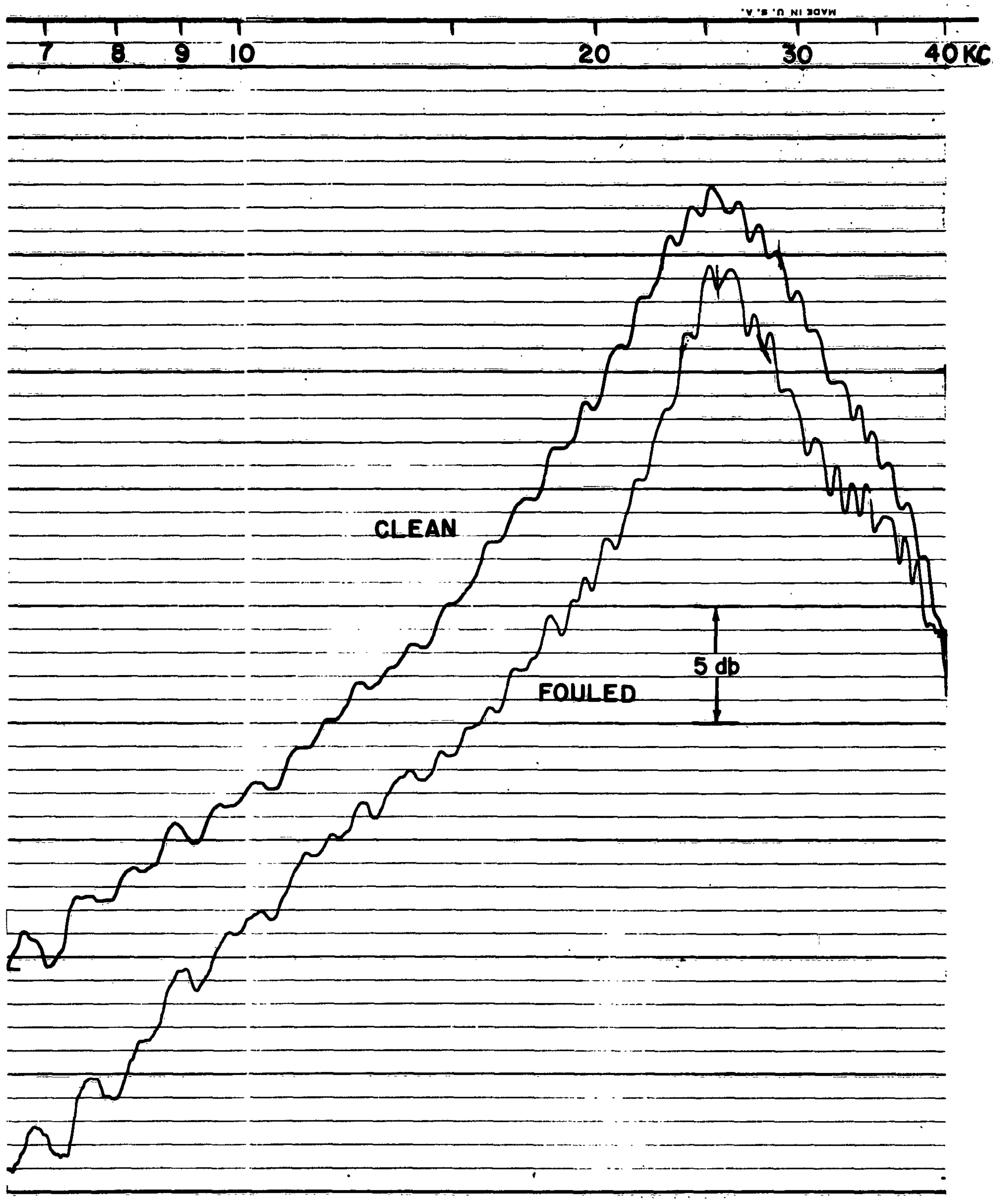



FIG. 15 HYDROPHONE NO. 3, AXIAL RESPONSE, 7-40 KC.

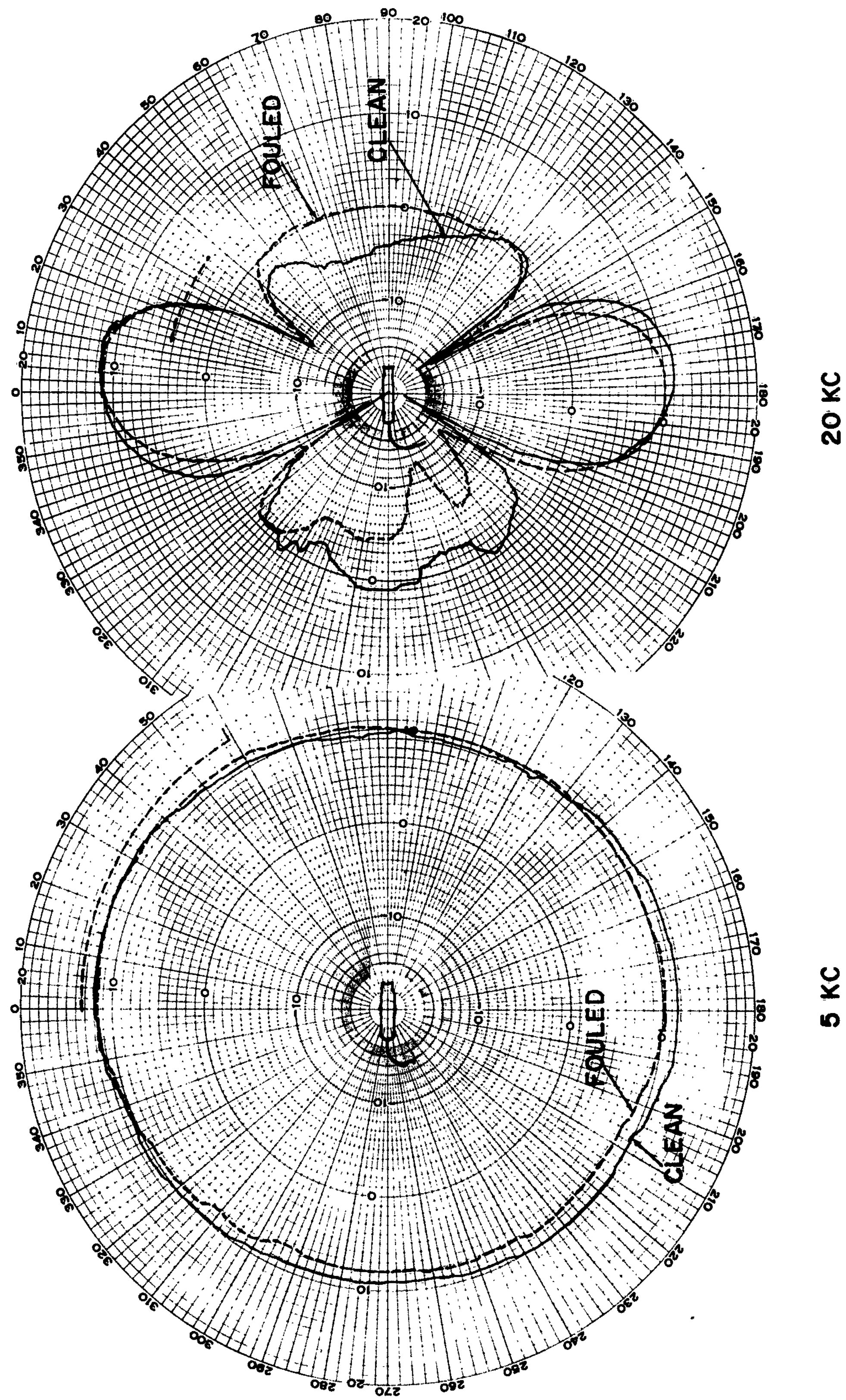



FIG. 16 HYDROPHONE NO. 4, PATTERNS IN PLANE CONTAINING THE AXIS AT 5 AND 20 KC.

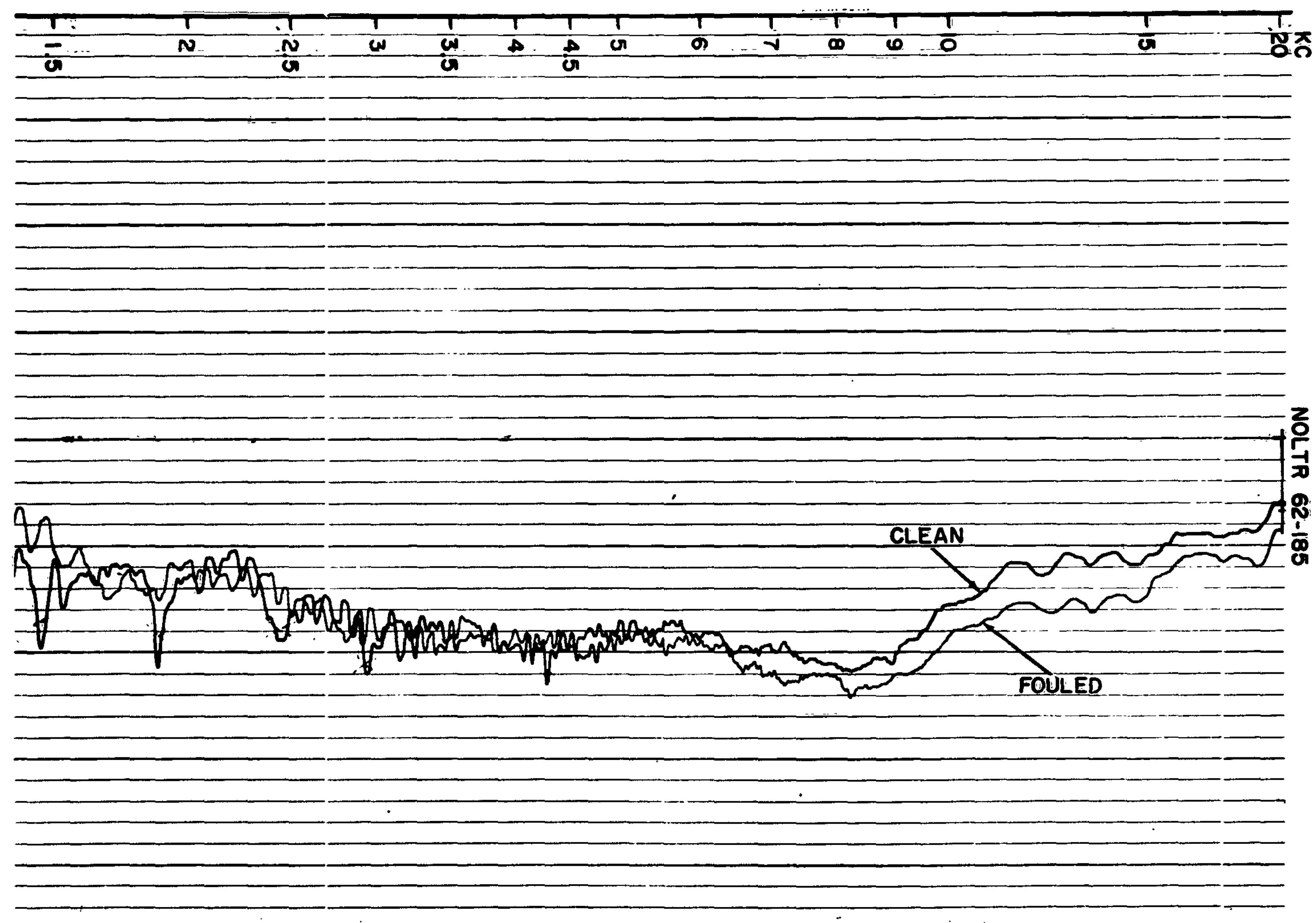



FIG. 17 HYDROPHONE NO. 4, AXIAL RESPONSE, 1-20 KC.

| | Copies |
|---|---|
| Director<br>National Oceanographic Data Center<br>Washington 25, D. C. | 1 |
| Commanding Officer<br>U. S. Navy Mine Defense Laboratory<br>Panama City, Florida | 1 |
| Bingham Oceanographic Laboratories<br>Yale University<br>New Haven, Connecticut | 1 |
| Director<br>Hawaiian Marine Laboratory<br>University of Hawaii<br>Honolulu, Hawaii | 1 |
| Head, Department of Oceanography and Meteorology<br>Texas A & M College<br>College Station, Texas | 1 |
| Director<br>Arctic Research Laboratory<br>Barrow, Alaska | 1 |
| Director<br>Bermuda Biological Station for Research<br>St. Georges, Bermuda | 1 |
| Director<br>Marine Physical Laboratory<br>San Diego 52, California | 1 |
| Director<br>Scripps Institution of Oceanography<br>La Jolla, California | 1 |
| Department of Meteorology & Oceanography<br>U. S. Naval Postgraduate School<br>Monterey, California | 2 |
| Director<br>Lamont Geological Observatory<br>Torrey Cliff<br>Palisades, New York | 1 |

| | Copies |
|---|---|
| Director<br>Naval Research Laboratory<br>Washington 25, D. C.<br>Attn: Technical Services Information Officer<br>Code 5520<br>Code 5540 | 3 |
| National Research Council<br>2101 Constitution Avenue<br>Washington 25, D. C.<br>Attn: Committee on Undersea Warfare<br>Committee on Oceanography | 2 |
| Director<br>Bureau of Commercial Fisheries<br>U. S. Fish and Wildlife Service<br>Department of Interior<br>Washington 25, D. C. | 2 |
| Director<br>Narragansett Marine Laboratory<br>University of Rhode Island<br>Kingston, Rhode Island | 1 |
| Director<br>Coast and Geodetic Survey<br>U. S. Department of Commerce<br>Washington 25, D. C.<br>Attn: Office of Oceanography | 1 |
| Commandant (OFU)<br>U. S. Coast Guard<br>Washington 25, D. C. | 1 |
| U. S. Bureau of Commercial Fisheries<br>Fish and Wildlife Service<br>P. O. Box 271<br>La Jolla, California | 1 |
| Superintendent<br>U. S. Naval Academy<br>Annapolis, Maryland | 1 |
| Gulf Coast Research Laboratory<br>Post Office Box<br>Ocean Springs, Mississippi<br>Attn: Librarian | 1 |

| | Copies |
|---|---|
| Commanding Officer & Director<br>U. S. Navy Electronics Laboratory<br>San Diego 52, California<br>Attn: Code 2201<br>Code 2420 | 3 |
| Commanding Officer and Director<br>David Taylor Model Basin<br>Washington 7, D. C. | 1 |
| Commander<br>U. S. Naval Ordnance Test Station<br>3202 E. Foothill Boulevard<br>Pasadena, California | 1 |
| Director<br>U. S. Naval Engineering Experimental Station<br>Annapolis, Maryland | 1 |
| Commanding Officer<br>U. S. Naval Underwater Ordnance Station<br>Newport, R. I. | 1 |
| Laboratory Director<br>Bureau of Commercial Fisheries Biological Laboratory<br>U. S. Fish and Wildlife Service<br>Washington 25, D. C. | 1 |
| Commanding Officer<br>U. S. Navy Air Development Center<br>Johnsville, Pennsylvania<br>Attn: NADC Library | 1 |
| Commanding Officer<br>U. S. Naval Underwater Sound Laboratory<br>New London, Connecticut | 1 |
| Oceanographer<br>U. S. Oceanographic Office<br>Washington 25, D. C.<br>Attn: Library (Code 1640) | 3 |
| Commanding Officer and Director<br>U. S. Naval Civil Engineering Laboratory<br>Port Hueneme, California<br>Attn: Code L54 | 1 |

## DISTRIBUTION LIST

| | Copies |
|---|---|
| Armed Services Technical Information Agency<br>Arlington Hall Station<br>Arlington 12, Virginia | 10 |
| Office of Technical Services<br>Department of Commerce<br>Washington 25, D. C. | 1 |
| Director of Defense Research & Engineering<br>Pentagon<br>Washington 25, D. C.<br>Attn: Coordinating Committee on Science | 1 |
| Chief, Bureau of Naval Weapons<br>Department of the Navy<br>Washington 25, D. C.<br>Attn: FASS<br>RU-222<br>RUDC-2<br>RUDC-3 | 4 |
| Chief, Bureau of Ships<br>Department of the Navy<br>Washington 25, D. C.<br>Attn: Code 312<br>Code 341C<br>Code 631<br>Code 688<br>Code 345<br>Code 689<br>Technical Library | 7 |
| Office of Naval Research<br>Washington 25, D. C.<br>Attn: Biology Branch (Code 446)<br>Surface Branch (Code 463)<br>Undersea Warfare (Code 466)<br>Special Projects (Code 418)<br>Acoustics Branch (Code 468) | 5 |
| Director<br>U. S. N. Underwater Sound Reference Laboratory<br>Orlando, Florida | 3 |

| | Copies |
|---|---|
| Director<br>Chesapeake Bay Institute<br>Johns Hopkins University<br>121 Maryland Hall<br>Baltimore 18, Maryland | 3 |
| Head, Department of Oceanography<br>University of Washington<br>Seattle 5, Washington | 1 |
| Director<br>Woods Hole Oceanographic Institution<br>Woods Hole, Massachusetts | 2 |
| Director<br>Hudson Laboratories<br>145 Palisades Street<br>Dobbs Ferry, New York | 1 |
| Technical Information Center, CU-201<br>Lockheed Missile and Space Division<br>3251 Hanover Street<br>Palo Alto, California | 1 |
| Director, Marine Laboratory<br>University of Miami<br>#1 Rickenbacker Causeway<br>Virginia Key<br>Miami 49, Florida | 1 |
| Oceanographic Institute<br>Florida State University<br>Talahassee, Florida | 1 |
| Ordnance Research Laboratory<br>Pennsylvania State University<br>University Park, Pennsylvania | 1 |
| Chesapeake Biological Laboratory<br>Solomons, Maryland | 3 |

CATALOGING INFORMATION FOR LIBRARY USE

BIBLIOGRAPHIC INFORMATION

| | DESCRIPTORS | CODES | | DESCRIPTORS | CODES |
|---|---|---|---|---|---|
| SOURCE | NOL Technical report | NOLTR | SECURITY CLASSIFICATION AND CODE COUNT | Unclassified - 22 | UØ22 |
| REPORT NUMBER | 62-185 | 62Ø185 | CIRCULATION LIMITATION | | |
| REPORT DATE | 21 November 1962 | 1162 | CIRCULATION LIMITATION OR BIBLIOGRAPHIC | | |
| | | | BIBLIOGRAPHIC (SUPPL., VOL., ETC.) | | |

SUBJECT ANALYSIS OF REPORT

| DESCRIPTORS | CODES | DESCRIPTORS | CODES | DESCRIPTORS | CODES |
|---|---|---|---|---|---|
| Marine | MARI | Deterioration | DETE | | |
| Fouling | FOUL | Beam | BEAM | | |
| Transducers | TRAD | Pattern | PATT | | |
| Acoustic | ACOU | Measurement | MEAU | | |
| Effects | EFFE | Chesapeake Bay | CHES | | |
| Underwater | UNDE | Receiving | RECP | | |
| Objects | OBJE | Response | RESP | | |
| Organisms | ORGS | Axial | AXIA | | |
| Life | LIFE | Surveillance | SURE | | |
| Hydrophone | HYDR | Systems | SYST | | |
| Reduction | REDC | | | | |
| Sensitivity | SENV | | | | |

PRNC-NOL-5070/28 (5-62)

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-185)
ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS (U), by R. J. Urick. 21 Nov. 1962. 11p. illus., charts. UNCLASSIFIED

A small selection of hydrophones were measured after they had remained in Chesapeake Bay during the growing season of 1961. Measurements of beam pattern and receiving response were made in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to 10 db were found in the frequency interval 1 to 20 kc. Appreciable, though not severe, effects of the fouling on the hydrophone beam patterns were observed.

1. Transducers, Acoustic
2. Hydrophones - Fouling
3. Hydrophones - Sensitivity
I. Title
II. Urick, Robert J.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-185)
ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS (U), by R. J. Urick. 21 Nov. 1962. 11p. illus., charts. UNCLASSIFIED

A small selection of hydrophones were measured after they had remained in Chesapeake Bay during the growing season of 1961. Measurements of beam pattern and receiving response were made in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to 10 db were found in the frequency interval 1 to 20 kc. Appreciable, though not severe, effects of the fouling on the hydrophone beam patterns were observed.

1. Transducers, Acoustic
2. Hydrophones - Fouling
3. Hydrophones - Sensitivity
I. Title
II. Urick, Robert J.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-185)
ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS (U), by R. J. Urick. 21 Nov. 1962. 11p. illus., charts. UNCLASSIFIED

A small selection of hydrophones were measured after they had remained in Chesapeake Bay during the growing season of 1961. Measurements of beam pattern and receiving response were made in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to 10 db were found in the frequency interval 1 to 20 kc. Appreciable, though not severe, effects of the fouling on the hydrophone beam patterns were observed.

1. Transducers, Acoustic
2. Hydrophones - Fouling
3. Hydrophones - Sensitivity
I. Title
II. Urick, Robert J.

Naval Ordnance Laboratory, White Oak, Md.
(NOL technical report 62-185)
ACOUSTIC EFFECTS OF MARINE FOULING ON TRANSDUCERS (U), by R. J. Urick. 21 Nov. 1962. 11p. illus., charts. UNCLASSIFIED

A small selection of hydrophones were measured after they had remained in Chesapeake Bay during the growing season of 1961. Measurements of beam pattern and receiving response were made in the fouled condition and after the fouling had been cleaned off. Reductions of axial sensitivity ranging from zero to 10 db were found in the frequency interval 1 to 20 kc. Appreciable, though not severe, effects of the fouling on the hydrophone beam patterns were observed.

1. Transducers, Acoustic
2. Hydrophones - Fouling
3. Hydrophones - Sensitivity
I. Title
II. Urick, Robert J.